Cassini Maneuver Experience: Launch and Early Cruise

by
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The Cassini project is an international effort to study the planet Saturn and its moons with an orbital tour. The European Space Agency's (ESA) Huygens probe will be delivered to Saturn's moon Titan by the Cassini spacecraft. This is the first mission to visit Saturn since the flybys made by the two historic Voyager spacecraft in 1980 and 1981. Cassini will arrive at Saturn in 2004, the climax of a long journey that has just begun. This paper reports on the early experiences of the Cassini mission, with a focus on trajectory correction maneuvers. As of May 15, 1998, the strategy for the fourth such maneuver was executed. These four maneuvers are the focus herein, although plans and strategies for future maneuvers are mentioned as well.

The interplanetary trajectory to Saturn requires four gravity-assists, two from Venus, one from Earth, and another from Jupiter. This trajectory, referred to as VVEJGA, is depicted below.

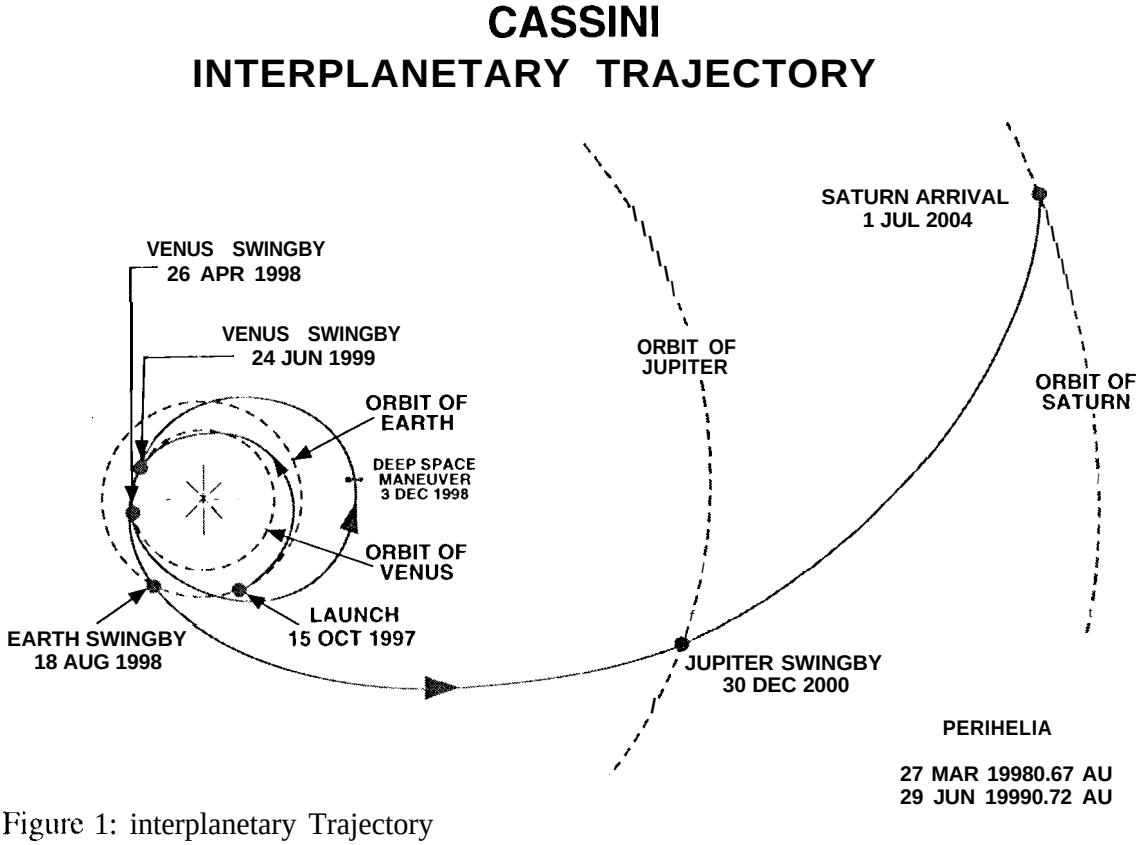
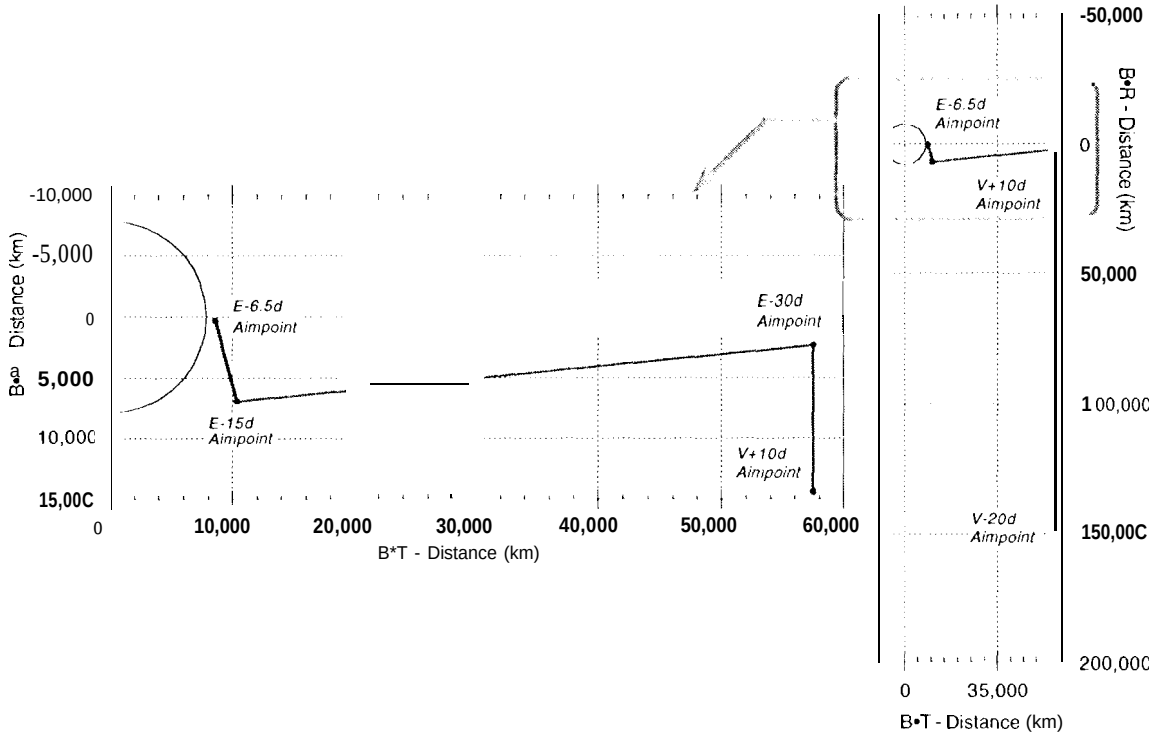


Figure 1: interplanetary Trajectory

There are seven years between launch and arrival at Saturn. There are roughly 6.5 months between launch and the first Venus swingby, 14 months between the two Venus swingbys, and 55 days between the second Venus swingby and the Earth swingby. The Jupiter swingby is about one-third of way into the subsequent 5 years. Although, no science investigations are planned, there are many activities to be accomplished within this time, including the execution of21 trajectory correction maneuvers (TCMs).



Launch

The Cassini spacecraft was launched on October 15, 1997 by a Titan IV rocket with a Centaur upper stage. Together, these vehicles provided Cassini with a launch energy in excess of XX m^2/s^2. After separation from Cassini, the Centaur executed a collision and contamination avoidance maneuver (C/CAM). The C/CAM ensured that the Centaur would flyby Venus clays later and thousands of kilometers further away than Cassini.
The launch delivered the spacecraft on a trajectory very c1osc to the desired trajectory. The post-launch (pre-TCM-1) Venus flyby prediction is represented in the figure below. The B•R, B•T coordinates relate to the B-plane and are discussed in the appendix.

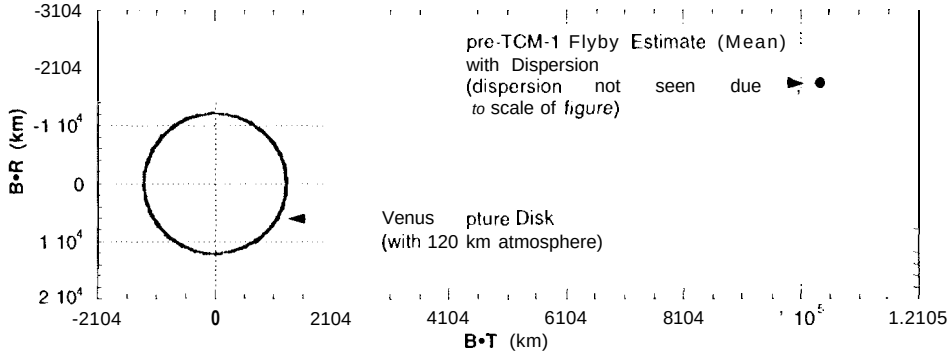


Figure 2: Venus Swingby, predicted from post-launch conditions

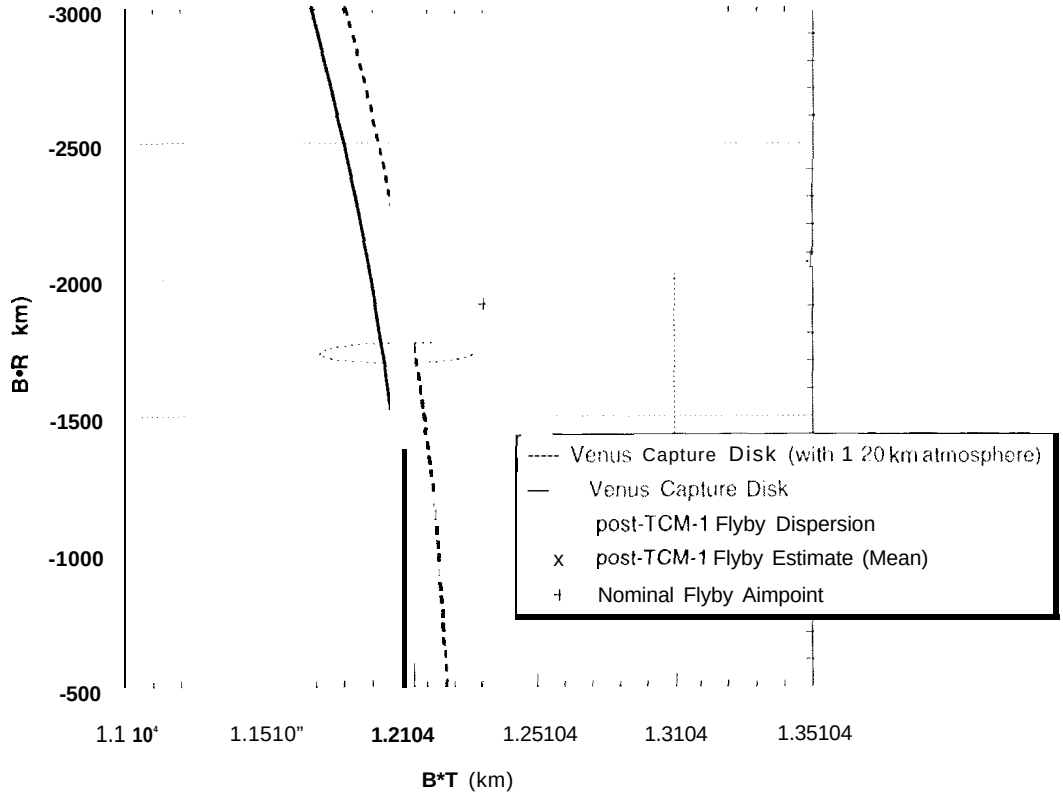
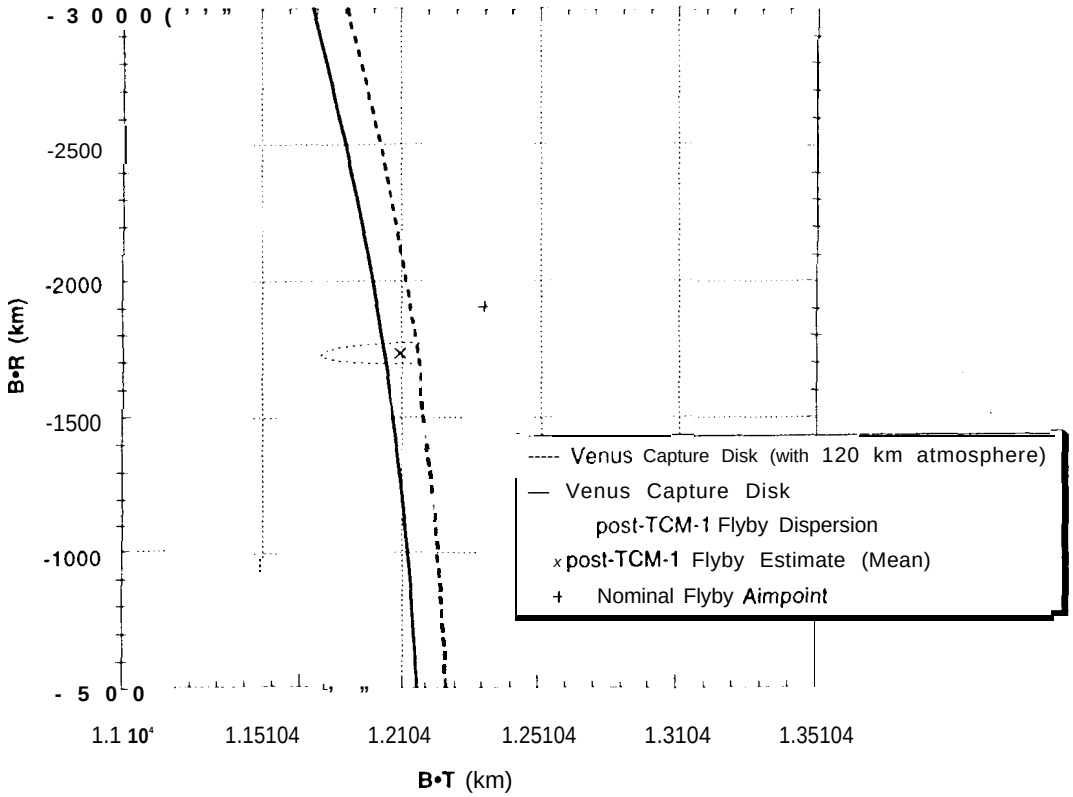


Figure 3: Venus Swingby, predicted from post-TCM- 1 conditions

The execution of this maneuver yielded some excitement, although there were no seriously threatening anomalies. First, the main engine was fired at temperatures and pressures above those used during flight qualification testing. This was due to some unexpected heating from the Radioisotope Thermoelectric Generators (RTGs) and a small leak in the pressure regulator. Motivated by this leak, the system was operated in a blow-down mode, , isolated from the regulator, although the original plan was to allow the pressure to be regulated during the firing. Second, slight errors in the ground-estimate of the spacecraft's center of mass were found to cause a 10.7 milliradian pointing error.

TCM-2

The second TCM was designed to clean-up after the first, occuring about 108 days later on February 25, 1998. After the execution of TCM-1 was analyzed by the flight team, it was determined that a 90 mm/s maneuver would bc required to tweak the trajectory so that the desired swingby conditions would bc achieved (and Venus-impact avoided). As of the "Launch +47 day" prediction, execution of TCM-2 would probably eliminate the need for TCM-3. The results of execution are TBD.



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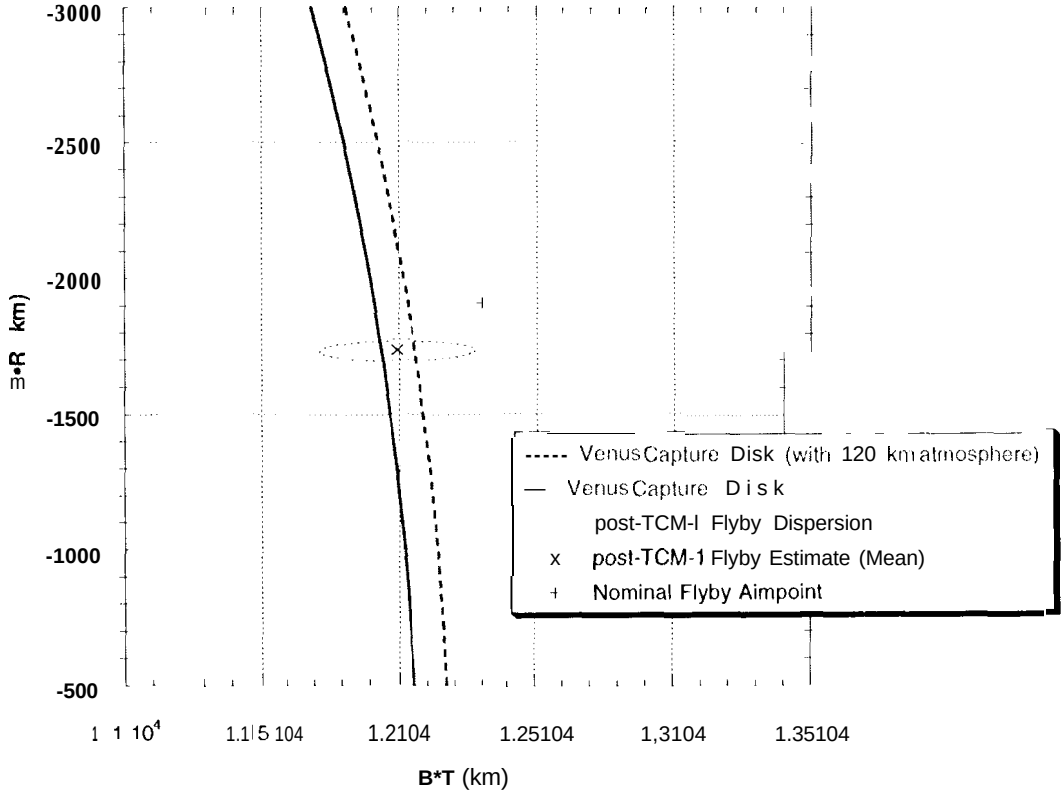

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